



Development of Project-Based Interactive Multimedia for Science to Improve Critical Reasoning in Elementary School Students

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Abstract: The low critical reasoning ability of elementary school students in science learning requires learning innovations that are able to integrate technology, project activities, and active student involvement. This study aims to develop interactive multimedia science based on projects and test its validity and effectiveness in improving critical reasoning of elementary school students. The type of research used is research and development (R&D) with the ADDIE model, which consists of the stages of analysis, design, development, implementation, and evaluation. Quantitative data were collected through questionnaires, observations and critical reasoning questions, while qualitative data were obtained from suggestions and validators of media and materials. The product was tested on 39 students from two elementary schools in Klaten Regency. The sample in this study was selected using a purposive random sampling technique. Data were analyzed using t-tests and N-gain tests to determine the effectiveness of the product in improving critical reasoning. The results of the study showed that the validation of media and materials each obtained a percentage of 87.92% (feasible) and 93.69% (very feasible), and the results of the t-test showed a probability value of $0.004 < 0.05$ which indicated a significant influence on improving students' critical reasoning. The results of the N-gain test also showed an increase in students' critical reasoning after the use of project-based interactive multimedia for science and technology. Therefore, it can be concluded that project-based interactive multimedia for science and technology meets the criteria of feasibility and effectiveness so that it can be applied in science and technology learning in elementary schools.

Keywords: Critical reasoning; Interactive multimedia; Projects; Science

Introduction

Education plays a crucial role in improving the quality of human life (Ramadhana & Meitasari, 2023). The concept of lifelong learning is considered a crucial educational concept in addressing the current rapid flow of change. This flow of change serves as the foundation for improving the quality of life in the 21st century (Meyer & Norman, 2020; Nurhayati & Lahagu, 2021; Oktaviany, 2023). The National Education Association introduced the concept of 21st-century skills known as "The 4Cs" (Erdogan, 2020). The 4Cs encompass critical

thinking and problem-solving, communication, collaboration, and creativity and innovation. These skills are essential for students to play an active role in real life (Wibowo et al., 2018).

Students need to possess competencies and knowledge relevant to 21st-century learning, such as critical thinking skills. Critical thinking is a cognitive process that includes the ability to analyze, evaluate, draw conclusions, and solve problems (Chen, 2017; Jatmiko et al., 2018; Rodzalan & Saat, 2015). Critical thinking skills can be improved through analysis,

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reasoning, decision-making, and observation (Thornhill-Miller et al., 2023; Yulianti & Gunawan, 2019).

Critical reasoning is closely linked to science learning in elementary schools because science learning not only conveys facts but also trains students to ask questions, investigate, and analyze. This effectively instills critical thinking skills in students (Prafitasari et al., 2021). Furthermore, two key components of science education in schools are scientific literacy and critical thinking (Vieira & Tenreiro-Vieira, 2016). In line with this statement, Hayati et al. (2023) stated that studying science as part of a comprehensive education helps students develop critical and creative thinking skills, logical reasoning, and the initiative they need to address social problems posed by advances in science and technology.

A preliminary study on the critical reasoning skills of elementary school students in Delanggu District found that they were classified as low. This was confirmed by a questionnaire distributed to 130 elementary school teachers in Delanggu District, Klaten Regency, in September 2025. The results showed that 70% of teachers, or 91 teachers, assessed students' critical reasoning skills as low. The following presents the average results for critical reasoning skills.

Reasons cited by teachers include students' lack of courage in expressing their opinions, their inability to draw conclusions from reading material, their lack of questioning skills, their inability to relate material to real-world contexts, and their inability to express ideas. Furthermore, many students found it difficult to relate the material to real life.

The lack of innovative learning media that stimulate higher-order thinking skills has resulted in students becoming passive recipients of information rather than active problem solvers. If the root cause of this phenomenon is not immediately identified and solutions sought through this research, it is feared that this degradation of critical thinking skills will hamper students' competitiveness at higher levels of education and limit their ability to face increasingly complex global challenges.

One way to improve critical reasoning skills is by engaging and actively engaging students through the use of digital platforms. Digital platforms are chosen as a medium for students in the learning process. The use of digital platforms in education offers the support needed by students and teachers due to the flexibility and ease of the learning process (Demirkan & Tok, 2024).

Educators need to be able to identify digital platforms that can maximize the quality of their teaching. Digital platforms such as Genially and Canva have a positive role as interactive multimedia used in learning (Shalimar & Rukmana, 2025; Wahyuni et al., 2024). Interactive multimedia helps teachers convey

abstract material so that students can understand it well (Sukariasih et al., 2019). The use of interactive multimedia can deepen students' understanding of learning materials, which impacts learning outcomes diperoleh (Selviana & Andriani, 2025).

Genially can be combined with other media, such as YouTube, Google Forms, Spotify, and other online platforms to support media interaction. Research conducted by Rahayu et al. (2024) found that Genially can be accessed online, making it easier for teachers to create creative, effective, and innovative learning. Stimuli can be expanded through various interactive and innovative learning modes or methods to train students' critical thinking. One learning model that supports the development of critical thinking is project-based learning.

Project-based learning is an authentic learning model or strategy in which students plan, implement, and evaluate projects that have real-world applications outside the classroom (Zhang, 2022). This supports student engagement in problem-solving situations, improves the quality of learning, and leads to higher-level cognitive development. Project-based learning is believed to be highly beneficial for fostering the 4Cs identified by the 21st-century framework to support deeper student participation, including critical thinking, communication, collaboration, and creativity (Tafakur et al., 2023).

The Project-Based Learning model emphasizes challenging questions and complex tasks that encourage students to design solutions, solve problems, organize tasks, and produce concrete outcomes related to their learning (Ibarra-Sáiz et al., 2021; Megawati, 2024). Students who use this model to learn tend to be more creative and have better critical thinking skills.

More effective and meaningful learning can result from the development of interactive media integrated into a project-based model that meets the demands of teachers, students, and the curriculum (Yustina et al., 2020). Furthermore, integrating interactive media into classroom learning encourages the development of students' critical thinking skills (Rosida et al., 2018). This media provides flexibility, accessibility, and various interactive elements that can increase student learning motivation (Safaruddin et al., 2020; Sari et al., 2024).

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The novelty of this research lies in the use of project-based interactive multimedia to illustrate the improvement of students' critical reasoning skills. The urgency of this research is based on the growing need for critical reasoning skills in education and the workplace. The rapid development of technology and the increasing complexity of global issues necessitate equipping students with critical reasoning skills. Therefore, this research provides important insights into how project-based interactive media can be optimized to meet these needs.

Based on the description above, it is known that interactive multimedia plays a significant role in supporting students' learning to improve critical reasoning skills in science subjects. Therefore, research is needed to develop project-based interactive multimedia to improve critical reasoning skills in elementary school students.

Method

Research Design

This study used a research and development (R&D) method with the ADDIE model (Adeoye et al., 2024). A needs analysis was conducted to identify initial problems, followed by observations and interviews to identify classroom learning challenges.

The second stage in this research is design. The design process begins with establishing learning objectives, designing scenarios or teaching and learning activities, designing learning tools, learning materials, and evaluation tools. The researchers designed interactive multimedia for project-based science and natural sciences to minimize teacher-centered learning and improve critical thinking skills, problem-solving skills, and the relevance of the material to students' lives.

Project-based interactive multimedia for science and natural sciences that can be used as an alternative learning media by teachers in the science subject of the natural landscape around me and community professions. The final result is packaged in the form of a link or QR code for the interact platform. The product structure developed includes: (1) the cover section (introduction) consisting of the title, (2) the menu section containing any content that students can access, also acting as a home, (3) the content section containing the menu, especially the steps for working on the diorama project which are presented by providing information on each stage, and (4) the closing section containing practice questions along with a glossary, summary, and bibliography.

The fourth stage is implementation. Once the product has been declared feasible, it is then piloted. A limited trial was conducted with fourth-grade students at Tlobong State Elementary School. The results of the

limited trial were then revised, allowing researchers to conduct a large-scale trial (Jannah & Julianto, 2018). The large-scale trial involved fourth-grade B students at Gatak 1 Public Elementary School as the experimental class and fourth-grade A students as the control class. The implementation stage was conducted to determine the effectiveness of the product after using interactive multimedia project-based science lessons to improve critical reasoning. A critical reasoning test was also conducted at this stage to evaluate the quality of the tests administered, both before and after the treatment. The following is a summary of the research stages shown in Figure 1.

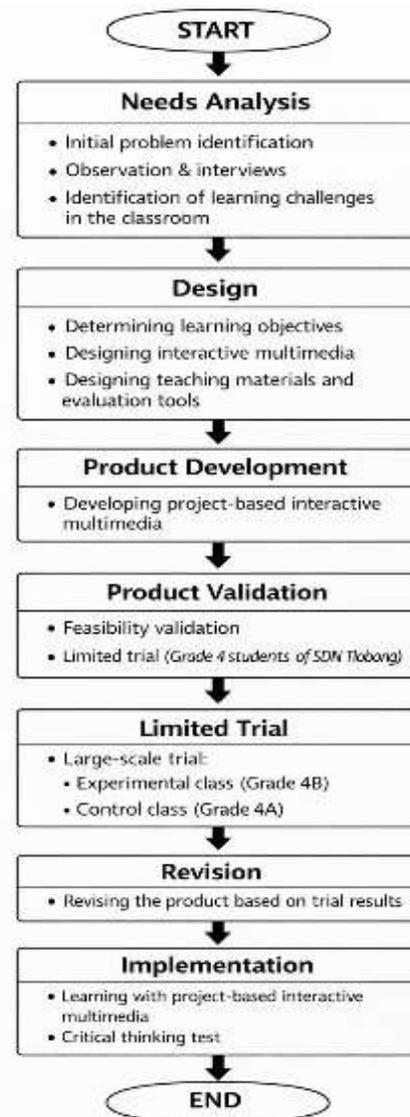


Figure 1. Flowchart of research and development stages

Participants

The data sources for this study were fourth-grade teachers and students in Klaten Regency. The sample was selected using a purposive sampling technique. The teachers selected were senior-grade teachers with

extensive science teaching experience and a willingness to fully participate in the validation and implementation stages of the product. A total of 39 students and two teachers participated in the implementation of the interactive multimedia science learning program.

Data Collection Techniques

This study used questionnaires (validation by media and material experts), observations, and cognitive tests. Material expert validation included aspects of material completeness, presentation, appropriateness of activity steps, appropriateness of material summary in multimedia, and practicality. Media expert validation included aspects related to inference, software engineering, visual and audio, navigation, and robustness. Practitioner validation consisted of several aspects ranging from subject matter, auxiliary information, affective consideration, pedagogy, interface, navigation, and robustness.

The observation sheet includes learning aspects (opening, main points, closing), media, methods, and instruments used. Meanwhile, the science literacy test includes aspects such as providing simple explanations, building basic skills, drawing conclusions, providing further explanations, and organizing strategies and tactics (Ennis, 2011).

Data Analysis

The data obtained in this study were qualitative and quantitative (Denny & Weckesser, 2022). Prior to analysis, the questionnaire data were converted into quantitative form and then analyzed using descriptive statistical methods. Data from observation processing and validator suggestions were analyzed qualitatively. The measurement scale used in this study was a Likert scale converted into percentages according to the reference (<25% means very inadequate, must be revised; 26-50% means less adequate, requires revision; 51-75% means adequate, with revisions according to expert advice); and 76-100 means very adequate, does not require revision) (Sugiyono, 2019).

Result and Discussion

Feasibility of Project-Based Interactive Multimedia Products for Science and Technology to Improve Critical Reasoning

The results of a questionnaire from 130 elementary school teachers in Klaten Regency showed that 62.3% of teachers answered that the level of critical reasoning of students was still low, 99.2% of teachers stated that appropriate learning media were needed to improve students' critical reasoning, and 71.5% of teachers hoped that media development could be innovated by utilizing digital platforms. Based on research conducted by Ismail et al. (2024) and Radhitya et al. (2025), students' low

critical reasoning skills are often caused by minimal exposure to contextual issues in learning. Similarly, Fuad et al. (2025) stated that most elementary school students struggle with intervention (drawing conclusions) and explanation (explaining phenomena). The average critical thinking score for students is still below the completion standard.

This was also supported by the results of observations conducted by researchers with an average percentage of 38.76% indicating that learning was lacking and needed improvement. In addition, the results of observations of critical reasoning also showed an average percentage of 34.92% which was in the poor category. The low observation results were caused by various factors such as limited use of media, less varied methods, and suboptimal critical reasoning assessment instruments. This condition indicates that teachers need the development of project-based interactive multimedia as an effort to improve students' critical reasoning.

The products developed are tailored to the learning materials and objectives. They utilize the Genially and Canva platforms, requiring an internet connection. Interactive multimedia can be accessed through <https://s.id/BalaProyekYuni>. This multimedia design has several components consisting of: (1) the content section of the material obtained from the book "Natural and Social Sciences Teacher's Guide Revised Edition" and the book "Natural and Social Sciences Revised Edition" by Amalia Fitri and the book "Natural and Social Sciences Learning (IPAS) by Suhelawati; (2) the interactive multimedia menu section based on the project contains: (a) the main menu consisting of the title of the material, class, level, and several icons or buttons such as home, back, next, click, and speaker), (b) the main menu page contains five submenus, namely the author's biography, learning achievements, learning objectives, starting learning, and fun quizzes, (c) the natural fortress page contains illustrations of natural landscapes, such as volcanoes, mountains, highlands, lowlands, rivers, lakes, and beaches, (d) the community profession page contains various types of professions, (e) the my project page contains six steps to carry out a simple project to make a natural fortress diorama from starting with essential questions, designing a plan, creating a schedule, monitoring the project, assessing the outcome, and evaluating the experience, (f) the Fun quizzes are conducted directly by selecting answers, (g) the glossary contains a collection of new terms used in interactive multimedia, and (h) the bibliography contains various sources used in compiling the material.

This project-based interactive multimedia product for science and education (IPAS) underwent one revision after undergoing a validation process by media and materials experts. The following are the results of

the validation by the materials experts on the developed learning media.

Table 1. Validation Results by Material Experts

No	Aspect	Validator 1	Validator 2
1	Inferce	3.88	3.12
2	Software engineering	4	3
3	Visual dan audio	3.83	3.33
4	Navigation	4	3
5	Durability	4	3
Average		3.94	3.09
Percentage		98.54%	77.29%
Average Percentage			87.92%

The average score from the two validators' assessments was 3.51, or an average percentage of 87.92%, categorized as feasible for implementation. Media experts also provided several constructive suggestions for improving interactive multimedia. First, improvements to the use of icons to ensure consistency across all pages. Consistency involves the same shape of each icon with the same function, color, and size from start to finish. This consistency aims to make it easier for users to recognize each icon and increase comfort in using interactive multimedia (Farooq et al., 2025). The results before and after the revision are shown in Figure 2.



Figure 2. Changes to the icon display

Second, improvements include changing the color of the connecting lines to make them appear or match the background color. Furthermore, improvements also need to be made by aligning the letter colors to match each component. This improvement aligns with visual design principles that emphasize color consistency and

contrast. The use of harmonious colors and appropriate contrast can enhance text and make it easier for users to process information (Hou et al., 2024). The following displays the changes before and after the revisions are shown in Figure 3.



Figure 3. Changes to the appearance of line, letter and background colors

Table 2. Material Expert Validation Results

No	Aspect	Validator 1	Validator 2
1	Completeness of Material	3,75	3,62
2	Presentation	3,4	3,7
3	Suitability of Activity Steps	4	4
4	Suitability of Material Summary to Media	3,5	3,5
5	Practicality Score	4	4
Average		3,73	3,77
Percentage		93,25%	94,13
Average Percentage			93,69%

The results of the material expert validation of the developed product are presented in Table 3. This validation aimed to ensure conceptual accuracy, the material's suitability to learning outcomes, and its support for the development of critical reasoning. Findings from the validation process were used as a reference for product revision.

The average score from the two validators' assessments was 3.75, or an average percentage of 93.69%, categorized as very feasible for implementation.

The material validator suggested adding instructions to the "Fun Quiz" feature. These additional instructions were intended to help students better understand the quiz flow and avoid errors in answering (Shoufan, 2023). These improvements aimed to increase clarity in the use

of the quiz feature and support the achievement of learning objectives in measuring students' critical reasoning. The following is a display of the changes before and after the revision, shown in Figure 4.



Figure 4. Changes to the appearance of the fun quiz page

Tables 2 and 3 show that the media and material validation results are in the feasible category, so they can be applied in fourth-grade science learning, especially on landscapes and community professions. This is in line with the results of research conducted by Sastradewi et al. (2022), which showed that the developed interactive media was assessed as very good. This is based on the assessment results from learning design experts, namely 91.10% and 90%, and from media experts at 94.40%. In line with research conducted by Riti et al. (2021), it shows that the developed learning model has been proven feasible, namely valid, practical, and effective, so it can be used in the teaching and learning process to improve students' critical thinking skills. Furthermore, research conducted by Pratiwi et al. (2023) showed a feasibility score for the media and learning content aspects reaching 0.93, meaning very feasible. The interactive multimedia based on the PjBL model has proven effective in improving student learning outcomes, especially on ecosystems material for fourth grade.

The Effectiveness of Project-Based Interactive Multimedia Products for Science in Improving Critical Reasoning

The results of this study were preceded by the implementation of validity and reliability tests in a limited trial conducted at Tlobong Public Elementary School. The results of the validity test showed that of the 25 items tested, only 14 items met the validity criteria. Based on the validity test of the test items, the results obtained were 14 critical reasoning test items had a calculated r value above 0.432, meaning the items were valid. Meanwhile, the results of the reliability test measured by Cronbach's Alpha obtained a result of 0.773. This result is in the range of $0.60 < r_{11} < 0.80$. This indicates that the results of the reliability test on the test

items are in the category of quite reliable (acceptable). Based on the results of the analysis, the data has met the requirements of validity and reliability, so it can be used as an instrument in a broad trial. Valid and reliable instruments are the main prerequisites in educational research so that the measurement results can be scientifically accounted for (Sugiyono, 2019).

Next, in the extensive trial phase, instruments that met validity and reliability criteria were used to collect research data. This was done to test the effectiveness of the developed product in a broader learning context (Lee & Fanguy, 2022). The extensive trial data were then presented in the form of pretest and posttest scores to observe changes in students' critical reasoning skills after using the product. The scores obtained from both groups are presented in the following table.

Table 3. Results of Pre-Test and Post-Test of Critical Reasoning Questions

Name of Public Elementary Scholl	Total	Pre-test	Post-test
1 Gatak			
Class A	20	60,90	72,11
Class B	19	61	83,65

Based on the above recapitulation of student learning outcomes in the pre-test and post-test in the experimental class and the control class, it is known that there is a difference in the average pre-test score between the two classes of 11.54. The average pre-test score in the experimental class was 61 and the control class was 60.90, while for the post-test, the experimental class obtained an average of 83.65 and the control class reached 72.11. These results indicate a significant increase in the average pre-test and post-test scores in both classes. Furthermore, a prerequisite test was carried out to ensure that the data obtained met the analysis

requirements according to the planned method, namely through a normality test and a homogeneity test.

The normality test was analyzed using the Shapiro-Wilk method, with data considered normal if the significance value was greater than 0.05. Shapiro-Wilk

was chosen as the analysis for the normality test because the sample size (students) was less than 60 (Demir, 2022). The results of the normality test for each group are presented in the following table.

Table 4. Normality Test Results

		Tests of Normality					
		Kolmogorov-Smirnova			Shapiro-Wilk		
	Class	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	Control	.143	19	.200	.946	19	.335
	Experiment	.198	20	.039	.926	20	.128
Post-test	Control	.169	19	.159	.919	19	.109
	Experiment	.152	20	.200	.922	20	.108

a. Lilliefors Significance Correction

Based on the table above, the significance value of the critical reasoning pre-test in the experimental group was 0.128 (> 0.05), while the control group obtained a significance value of 0.335 (> 0.05). For the post-test, the experimental group obtained a significance value of 0.108 (> 0.05), while the control group was 0.109 (> 0.05). The results of the normality test show that the pre-test and post-test scores in both groups have significance values above 0.05, thus indicating that the sample used in this study is normally distributed. This is in line with the opinion of Kwak (2023) who states that data is said to be normally distributed if the significance value is greater than 0.05.

In addition to the data being declared normally distributed, a homogeneity test was conducted to determine the similarity of variances between groups kelompok (Nahar et al., 2022). Based on the results of the

student post-test analyzed using the Levene's test, a significance value of 0.781 was obtained. This value is greater than 0.05, so it can be concluded that the data variance is equal or homogeneous (Odoi & Samita, 2022). After going through the prerequisite test, the data was declared to meet the requirements of being normally distributed and homogeneous, so further analysis could be continued with the independent samples t-test.

The effectiveness test in this study was conducted by comparing students' post-test learning outcomes. Effectiveness was measured using an independent samples t-test on two samples assuming equal variance, with a significance level of 5% ($\alpha = 0.05$) (Afifah et al., 2022). The complete calculation results are presented in Table 5.

Table 5. Independent Sample T-Test Results

		Independent Samples Test									
		Levene's Test for Equality of Variances		t-test for Equality of Means							
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% CI of the Diff.	Lower	Upper
Post test	Equal variances assumed	.073	.789	-3.03	37	.004	-11.55	3.808	-19.26	-3.83	
	Equal variances not assumed			-3.03	36.93	.004	-11.55	3.807	-19.26	-3.83	

The significance value of the t-test results obtained a result of 0.004 which means smaller than 0.05, so it can be concluded that there is a significant difference in the critical reasoning abilities of students in the control and experimental classes. This difference can also be seen from the results of the N-gain test which shows a value of 0.58 with a moderate category. This indicates that the use of interactive multimedia in project-based science is effective in improving the critical reasoning abilities of fourth-grade elementary school students. The increase in critical reasoning abilities is not only caused by the use of interactive multimedia as a learning medium but also the content contained in the product.

The application of interactive multimedia in science and natural sciences further enhances students' critical reasoning skills. Learning science and natural sciences through a project-based model facilitates student understanding. This is consistent with the findings of Zulyusri et al. (2023) who stated that the use of project-based learning (PjBL) methods leads to higher levels of creative and critical thinking skills. This is because the syntax of the PjBL model encourages students to actively participate in learning to maximize understanding and critical and creative thinking capacity.

According to Permana et al. (2021), project-based blended learning can improve students' critical thinking

skills. Consistent with the findings of this study, Hasanah et al. (2023) found that interactive multimedia based on scientific inquiry in science learning is effective and flexible in exploring abstract scientific concepts, thus improving students' critical thinking skills.

Conclusion

This study shows that project-based interactive multimedia for science learning in grade IV of elementary school has met the validity criteria and proven to be significantly effective in improving students' critical reasoning, as indicated by the t-test significance value of 0.004 ($p < 0.05$). The implications of this study confirm that the integration of digital technology and project-based learning (PjBL) models is a crucial strategy in transforming the role of teachers from primary sources of information to facilitators, thereby overcoming the obstacles of low courage to express opinions and analytical skills of students in elementary schools. Therefore, it is recommended for teachers to adopt this innovative media as a practical learning tool in the classroom, and for future researchers it is hoped that they can develop similar media with a wider scope of material or explore other higher-order thinking ability variables.

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Author Contributions

Conceptualization, YKA and YP; methodology, YKA; software, YKA; validation, YP and AFN; formal analysis, AFN; investigation, YKN; resources, ALM; data curation, YKA; writing—original draft preparation, YKA; writing—review and editing, ALM; visualization, YP; supervision, AFN & ALM; project administration, YP; funding acquisition, YKA.

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There is no conflict of interest.

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